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Field Tests of the Resistance of Hybrid Pines to the Pine Reproduction Weevil

by Ralph C. Hall

FOREST SERVICE - UNITED STATES
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PACIFIC SOUTHWEST
FOREST AND RANGE
EXPERIMENT STATION
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Work reported here was conducted by the former Bureau of Entomology and Plant Quarantine in cooperation with the Forest Service until the Department of Agriculture was reorganized in 1953. Thereafter it was continued by the Forest Service, which now does forest insect research.

U. S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE
PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION
(Formerly known as the California Forest and Range Experiment Station)

ABSTRACT

The backcross hybrid of Jeffrey and Coulter pines (Pinus jeffreyi x (P. jeffreyi x P. coulteri)) was tested from 1948 through 1956 in three field plantings on the Lassen and Shasta National Forests for resistance to the pine reproduction weevil, Cylindrocopturus eatoni Buch. The standard of comparison was Jeffrey pine, planted in alternate rows, which is highly susceptible to weevil damage. Two of the experimental plantings, at Mt. Shasta and Big Springs, were made in areas where weevil damage had been very serious in earlier brushfield plantings. The third, at McCloud Flat, was in an area where previous weevil damage had been very light.

The hybrid showed a marked resistance to weevil attack under field conditions, substantiating earlier findings in the nursery. Under equal exposure and chance of attack, 7 times as many Jeffrey pines as hybrids were killed. Besides resistance to the weevil, the hybrid had slightly better planting survival and a somewhat higher growth rate than its Jeffrey pine parent. These advantages add up to a promising tree to use in future brushfield plantations in northern California where damage from the weevil is frequently a limiting factor.

CONTENTS

Figure 1.--Hybrid test planting at Mt. Shasta in May 1958. (Photo by James L. Averell.)

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INTRODUCTION

In 1946 and 1947, J. M. Miller of the Forest Insect Laboratory at Berkeley conducted tests at the Institute of Forest Genetics at Placerville, California, to determine the relative resistance of various species of pines and their hybrids to attack and injury by the pine reproduction weevil (Cylindrocopturus eatoni Buch.). His work demonstrated that Coulter pine (Pinus coulteri D. Don) and the backcross hybrid of Jeffrey and Coulter pines (Pinus jeffreyi Grev. and Balf. x (P. jeffreyi x P. coulteri)) showed remarkable resistance to attack and injury by the reproduction weevil in caged tests under nursery conditions. 1/ The hybrid had been developed by collecting pollen from a naturally occurring hybrid of Jeffrey and Coulter pine in the San Jacinto Mountains in southern California and artificially pollinating conelets of two Jeffrey pine trees on the Eldorado National Forest.

Late in 1947, Miller proposed that the backcross hybrid and its parents be subjected to field tests, in areas where the weevil was known to be present, to determine if this apparent resistance would hold up under field conditions. His proposal was that three outplantings be attempted during the first season: One in the Big Springs brushfield, Lassen National Forest, where weevil damage had practically wiped out a large planting made in 1937; another in the Shasta brushfield planting, on the Shasta National Forest, where recent damage by the weevil had been severe; and a third in the McCloud Flats area, also on the Shasta National Forest, where weevil damage had been very light.

THE STUDY

The project had two principal aims: First, to compare the relative resistance of the hybrid and the parent Jeffrey pine against the pine reproduction weevil under field planting conditions. Second, to compare the overall performance of the hybrid and the Jeffrey pine parent under these conditions.

1/ Miller, J. M., Resistance of pine hybrids to the pine reproduction weevil. U. S. Forest Serv. Calif. Forest and Range Expt. Sta. Res. Note 68. 17 pp. Illus. 1950.

The general plan was to compare mortality and growth of 100 hybrids, 100 natural progenies of the Jeffrey pine parents, and 20 Coulter pines in each planting. Two-year-old seedlings of each were planted in alternate 20-tree rows at each site. To broaden the test, two parent Jeffrey pine seed trees were chosen, one in the westside Sierra pine type and the other in the east-side Sierra pine type. The Coulter pine stock, which was limited in quantity, was from several seed trees. Jeffrey and hybrid pine seedlings from the two seed sources were assigned to experimental rows at random. (For details of the experimental design and other procedures, see Methodology.)

Experimental plantings were set out in cleared brush-field areas in the spring of 1948 and all failed spots were replanted the next year. Beginning in 1950 the plantings were subjected to natural outbreak or forced attack of the weevil. Mortality was checked each year, and height growth at the end of the third and ninth growing seasons. Annual height growth was determined by measurements between internodes. This report, covering the period 1948 to 1956, is considered the final report for this study.

RESULTS

Mortality of Pine Species and Hybrids

The experimental plantings at Mt. Shasta and Big Springs demonstrated that the backcross hybrid Jeffrey x (Jeffrey x Coulter) has a very high degree of resistance to injury by the pine reproduction weevil under field conditions (figure 2). No trees were killed by the weevil in the McCloud Flat area.

The first attack and resultant mortality due to the weevil occurred in 1951, the third year after planting. That year and the next, the numbers of trees killed by the weevil (table 1) amounted to the following percent mortality:

	Jeffrey pine	Hybrid
Mt. Shasta	44.0	6.3
Big Springs	12.9	1.1
Both	27.9	3.7

From 1953 to 1956, the additional killing brought the percent mortality to these levels:

	Jeffrey pine	Hybrid
Mt. Shasta	64.0	7.3
Big Springs	23.7	4.2
Both	43.0	5.7

Trees killed by the weevil were in adjacent rows; thus, under equal exposure and chance of attack, seven times as many Jeffrey pines as hybrids were killed. This difference in mortality is strong confirmation of Miller's earlier finding that the backcross hybrid was resistant to weevil injury.

Figure 2.--A section of the Mt. Shasta planting showing a comparison between the growth and survival of Jeffrey and the hybrid, rows 7, 8, and 9. Hybrids in rows 7 and 9 had no mortality from weevils compared to 10 attacked and killed in the Jeffrey, row 8. Photo by James L. Averell, 5/8/58.

During the course of the study, information was collected on causes of mortality other than insects, the relative performance by seed source, and the effect of size of planting stock.

Mortality due to the effects of climate was comparatively light in the original stock for the first two years except among Coulter pines (table 2):

	Percent mortality	
	First year	Second year
Jeffrey pine	15.0	5.7
Coulter pine	55.0	8.3
Hybrid	11.3	4.0

Mortality was high in all replacement stock; it averaged 77.8 percent in the Jeffrey pine, 81.8 percent in the Coulter, and 50.0 percent in the hybrid. Taking both original and replacement stock

together, the 2-year averages were:

	Percent mortality
Jeffrey pine	28.4
Coulter pine	68.8
Hybrid	18.9

Clearly, the hybrid was superior to both parent species in 2-year survival.

Additional mortality due to climatic factors, probably low temperatures, occurred in Coulter pines the third and fourth years. By then all the residual Coulters at Big Springs and McCloud Flat had been killed; at Mt. Shasta 13 were still alive and showed no evidence of winter killing. These 13 were still living at the end of the ninth growing season.

Gophers killed many trees in the McCloud Flat planting. Damage was first noted in the spring of 1950; apparently while winter snow was still on the ground, gophers destroyed a solid block of 21 trees in the northwest corner of the planting. By the early spring of 1952 gophers had destroyed 58.0 percent of the Jeffrey stock, 100 percent of the Coulter stock, and 71.2 percent of the hybrids. At the end of the study, only 29 Jeffrey pines and 20 hybrids remained at McCloud Flat.

Seed source apparently had a bearing on mortality. The planting stock of the Jeffrey pine and the hybrids originated from westside and eastside Sierra seed trees, but the planting tests are located in the eastside region. The hybrid stock which originated from the eastside seed tree had a survival of 95.6 percent; that from the westside tree, 80.7 percent. The eastside Jeffrey progeny had an average survival of 92.9 percent; the westside, 78.2 percent. The difference in survival is highly significant in both cases, but susceptibility to weevil damage showed no significant difference between seed sources.

Size of the original planting stock also influenced mortality. There appeared to be a close association between the size of planting stock and subsequent planting survival. The smaller stock had the higher 2-year survival (table 3):

Height of planting stock (feet)	Percent survival	
	Jeffrey pine	Hybrid
0.30 - 0.49	94.8	100.0
.50 - .69	79.8	93.2
.70 - .89	65.2	86.9
.90 - 1.00	--	70.8
1.10 - 1.20	--	0

In this comparison, data from McCloud Flat are excluded because damage by gophers confuses the picture.

Height Growth of Pine Species and Hybrid

Height growth at the end of the nine growing seasons shows that on the average the larger planting stock produced the larger trees, but exceptions were numerous. The correlation between height at planting and total height growth, though mostly low but significant (table 4), was subject to a relatively high standard error of estimate--from 19 to 33 percent. For example, a hybrid .99 feet in height at the time of planting at Big Springs produced the largest tree in the group: 7.8 feet tall. Another hybrid, .98 feet in height at the time of planting in the same area, produced very nearly the smallest tree: 3.7 feet in height: Height at planting did not appear to be related to mortality from the reproduction weevil.

The hybrid outgrew the Jeffrey parent in all three plantings each year. It was possible to compare the growth of the Coulter species in only the Mt. Shasta planting. Here the hybrid was intermediate between the parent species in height growth (figure 3); total height growth averaged 6.81 feet for Coulter pine, 5.32 feet for the hybrid, and 4.18 feet for Jeffrey pine. Intermediate growth by the hybrid has also been observed at the Institute of Forest Genetics.

At Big Springs the average total height for Jeffrey pine was 4.68 feet; for the hybrid, 5.36 feet (figure 4). At McCloud Flat the average total height for Jeffrey was 2.22 feet; for the hybrid, 3.02 feet (figure 5). The average for all plantings was 3.69 feet for the Jeffrey and 4.53 feet for the hybrid. All these differences were highly significant (table 5).

Although the hybrid stock grew faster than the Jeffrey parent on the average, there were numerous exceptions to the average. Some hybrids were rather runty and some Jeffrey pines showed evidence of very good vigor, as can be seen by the following tabulation of the extremes of height growth in feet:

Planting	Largest tree		Smallest tree	
	Jeffrey	Hybrid	Jeffrey	Hybrid
Mt. Shasta	5.8	7.6	3.2	3.0
Big Springs	7.1	7.8	2.3	3.2
McCloud	4.4	4.8	1.1	1.0

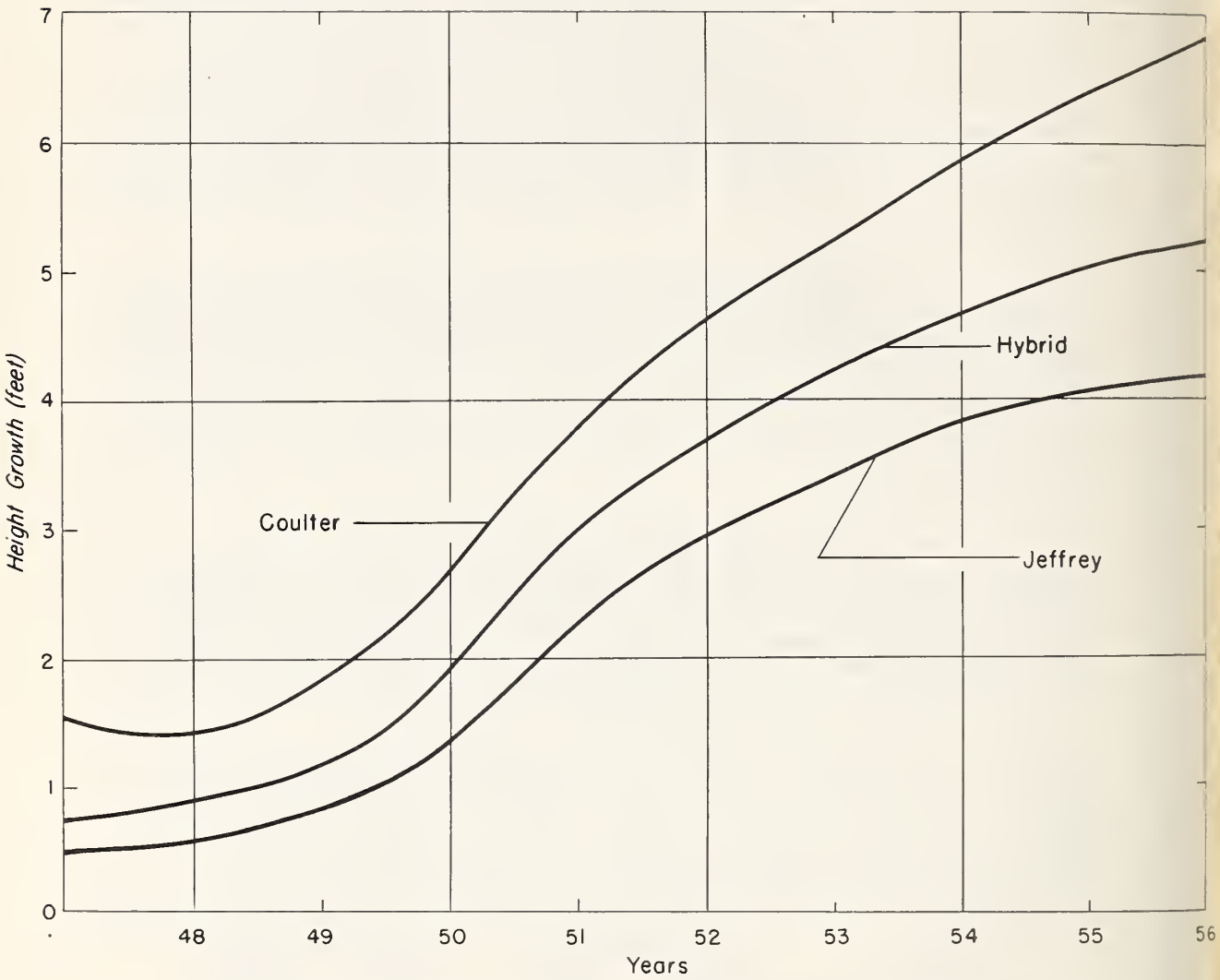


Figure 3. --Cumulative height growth by years and species, Mt. Shasta planting.

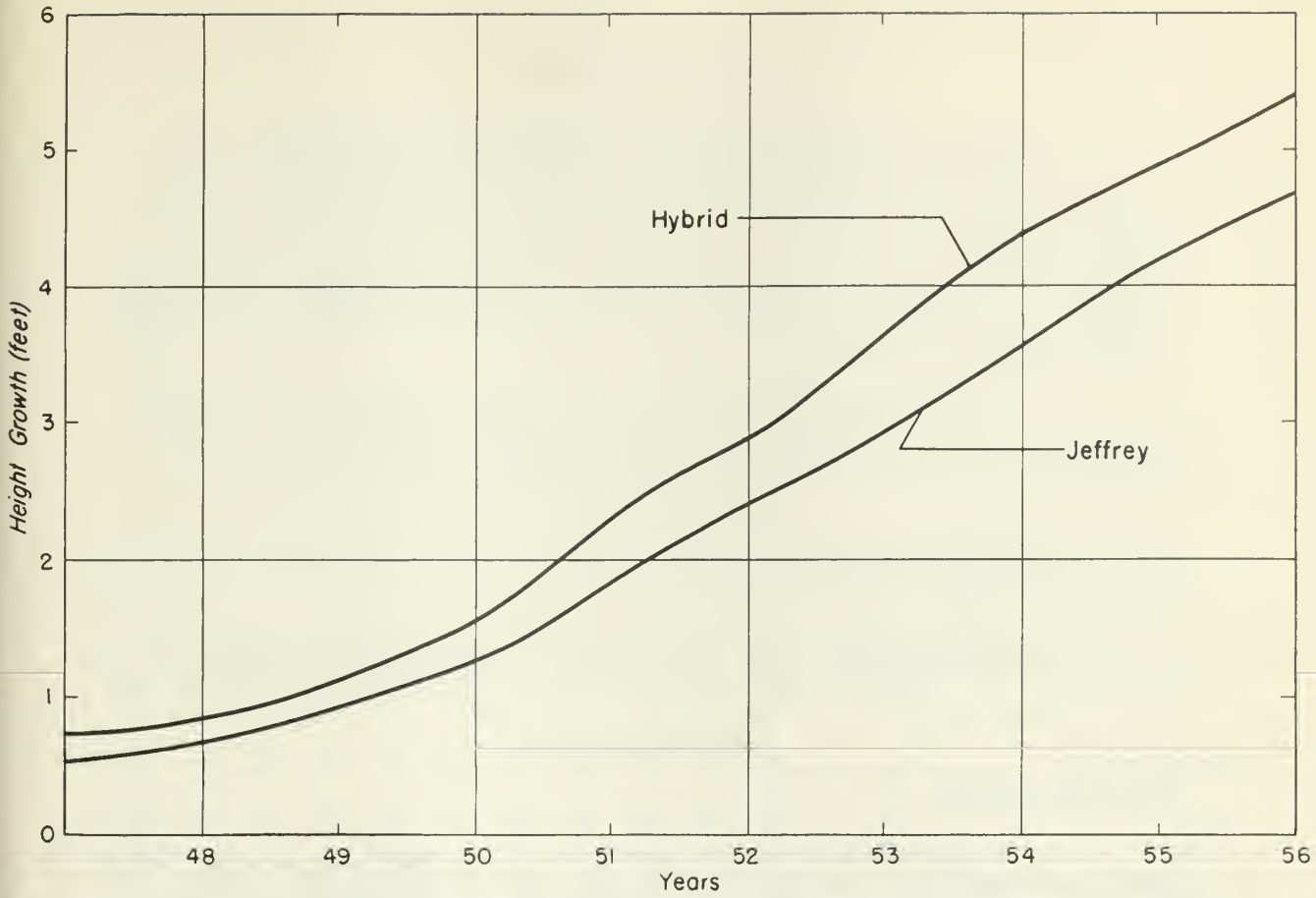


Figure 4. --Cumulative height growth by years and species, Big Springs planting.

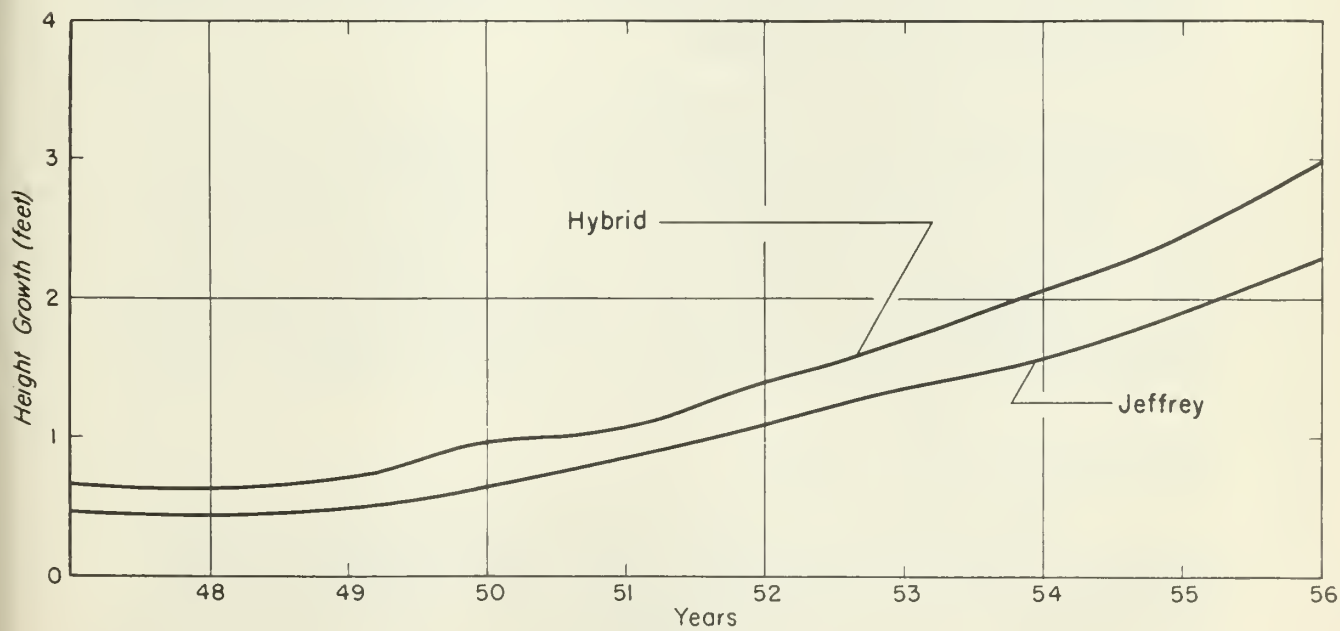


Figure 5. --Cumulative height growth by years and species, McCloud planting.

CONCLUSIONS

The two experimental plantings where weevil damage occurred have demonstrated quite conclusively that the backcross hybrid, Jeffrey x (Jeffrey x Coulter), has a high degree of resistance to attack and injury by the pine reproduction weevil under field planting conditions. In addition the hybrid grew significantly faster than the Jeffrey parent during the 9-year period of the test. Another advantage of the hybrid over the Jeffrey parent was the better planting survival.

These advantages add up to a rather superior tree for use in planting areas where the reproduction weevil might be expected to be a serious threat to pine plantations.

There was no difference in the susceptibility to the weevil in two different seed sources.

There appeared to be no relationship between height at planting and mortality from attacks by the reproduction weevil.

METHODOLOGY

Planting Design

A plan was prepared for each of the planting areas. This plan provided for 11 rows of 20 lines each, to accommodate 100 hybrids, 100 natural progeny of the Jeffrey pines from which the hybrids were obtained, and 20 Coulter pines (table 6). Provision for Coulter pine in these tests was limited to 20 seedlings in each because only a small amount of stock of this species was available and because winter kill of this species was expected. Spacing was 6 feet within and between rows.

To make the tests more comprehensive, hybrids and natural progenies from two seed trees were included in each experiment. The seed trees so represented were designated as P. J. -Eld-1-14 (westside Sierra, at an elevation of 6, 000 feet), and P. J. -Eld-5-3 (eastside Sierra, from an elevation of 6, 100 feet). In each test, allocation of the hybrid progenies from these trees to the hybrid or "H" rows was randomized. Allocation of the natural progenies to the Jeffrey or "J" rows was also randomized (figures 6, 7, 8). Random allocation of selected seedlings within rows was not attempted.

Selection of Planting Areas

The planting areas were selected with the help of supervisors and rangers of the Shasta and Lassen National Forests. The Big Springs planting site was located in the Big Springs Brushfield planting area of the Hat Creek District, Lassen National Forest,

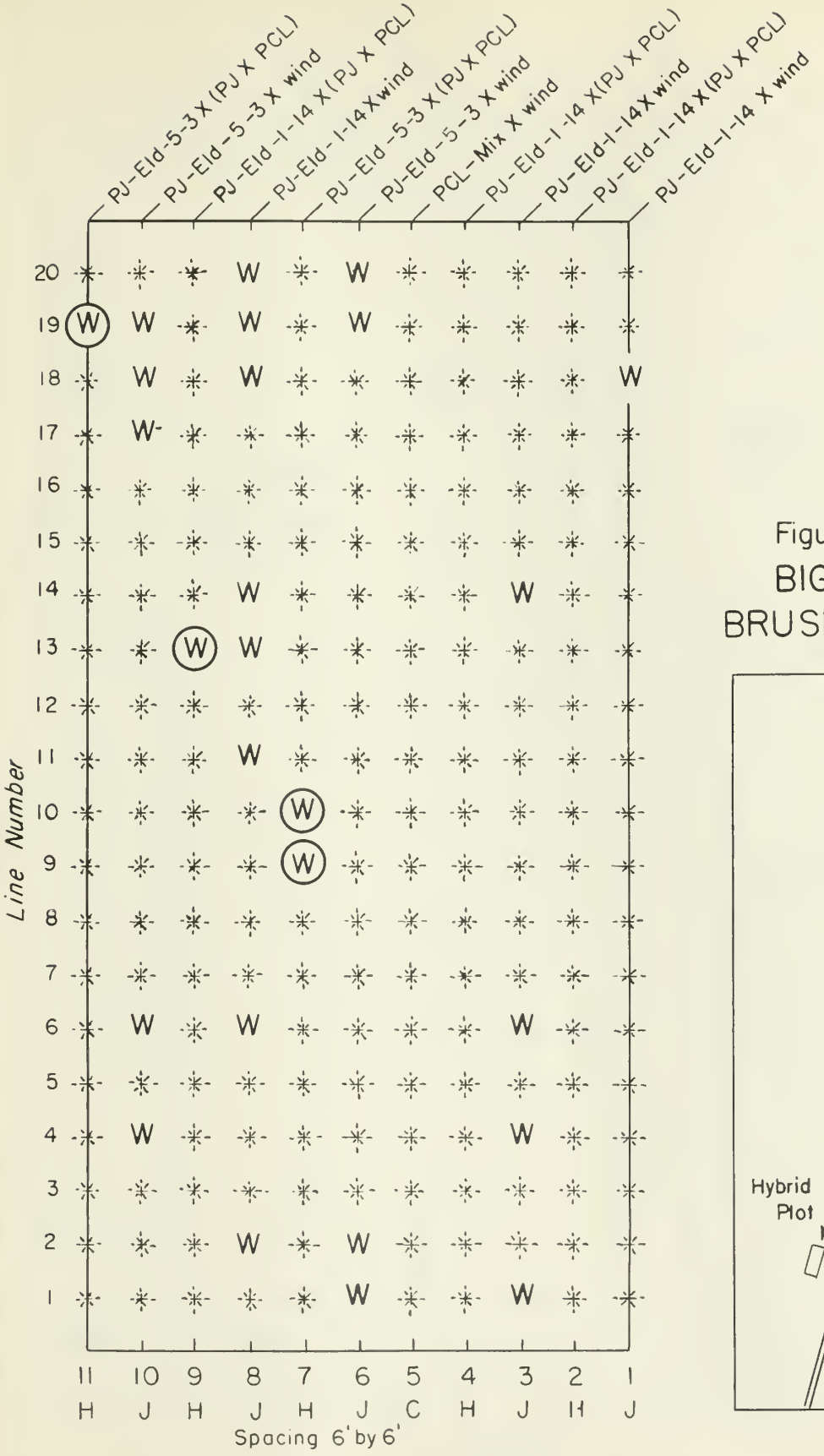
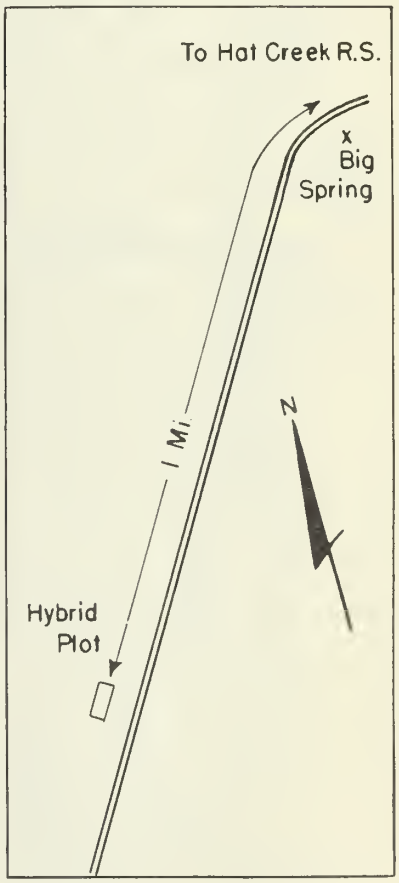


Figure 6

BIG SPRINGS BRUSHFIELD SITE



Legend

Planted Trees Killed by Pine Reproduction Weevil (W)=Hybrids, 4 W=Jeffrey Pine, 22

H=Hybrids J=Jeffrey C=Coulter

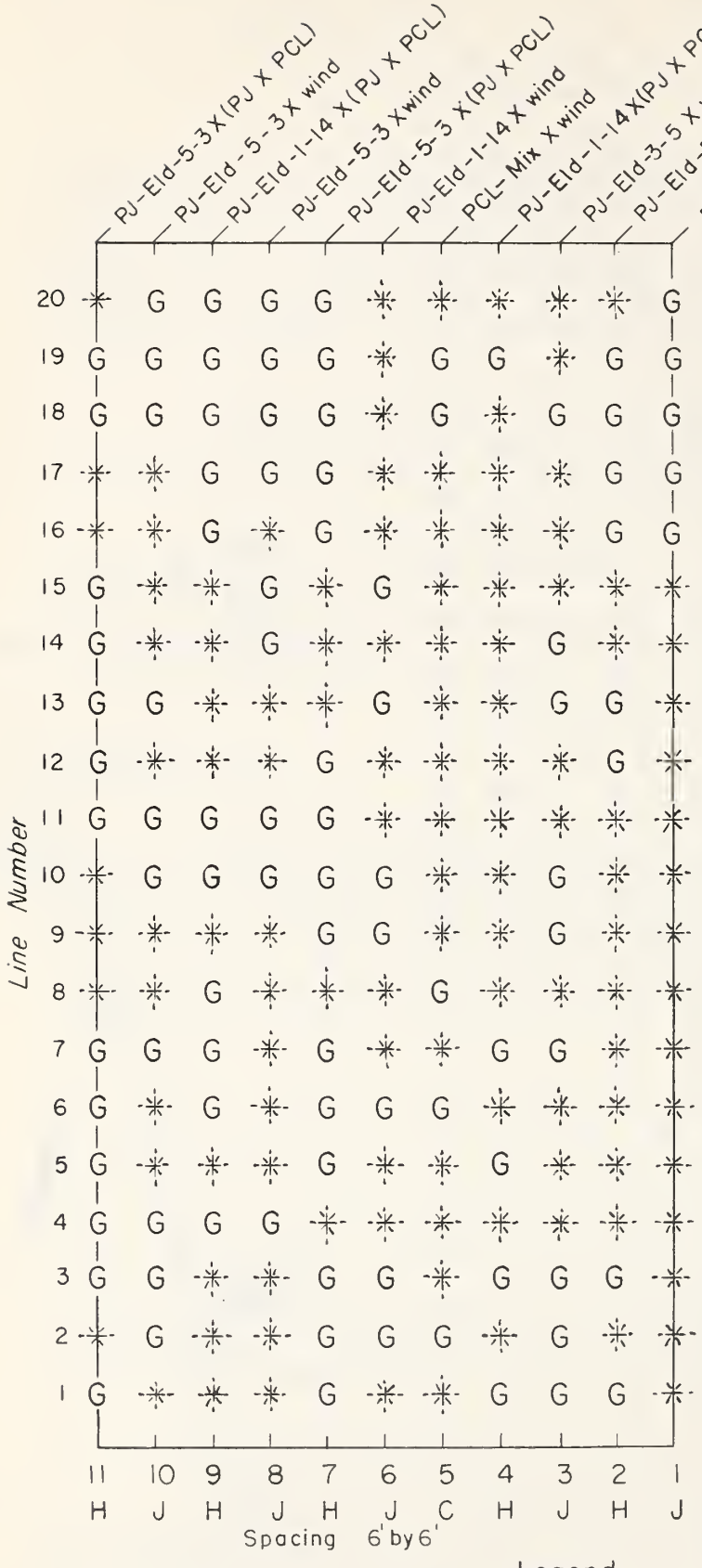
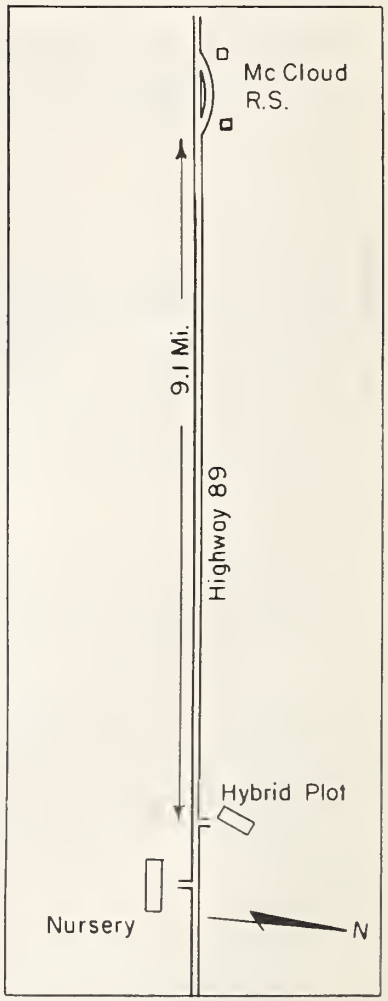


Figure 7

McCLOUD FLAT SITE



Legend

G = Trees Killed by Gophers — Jeffrey, 40; Hybrid, 52; Coulter, 5. No mortality - from weevils. H = Hybrid J = Jeffrey C = Coulter

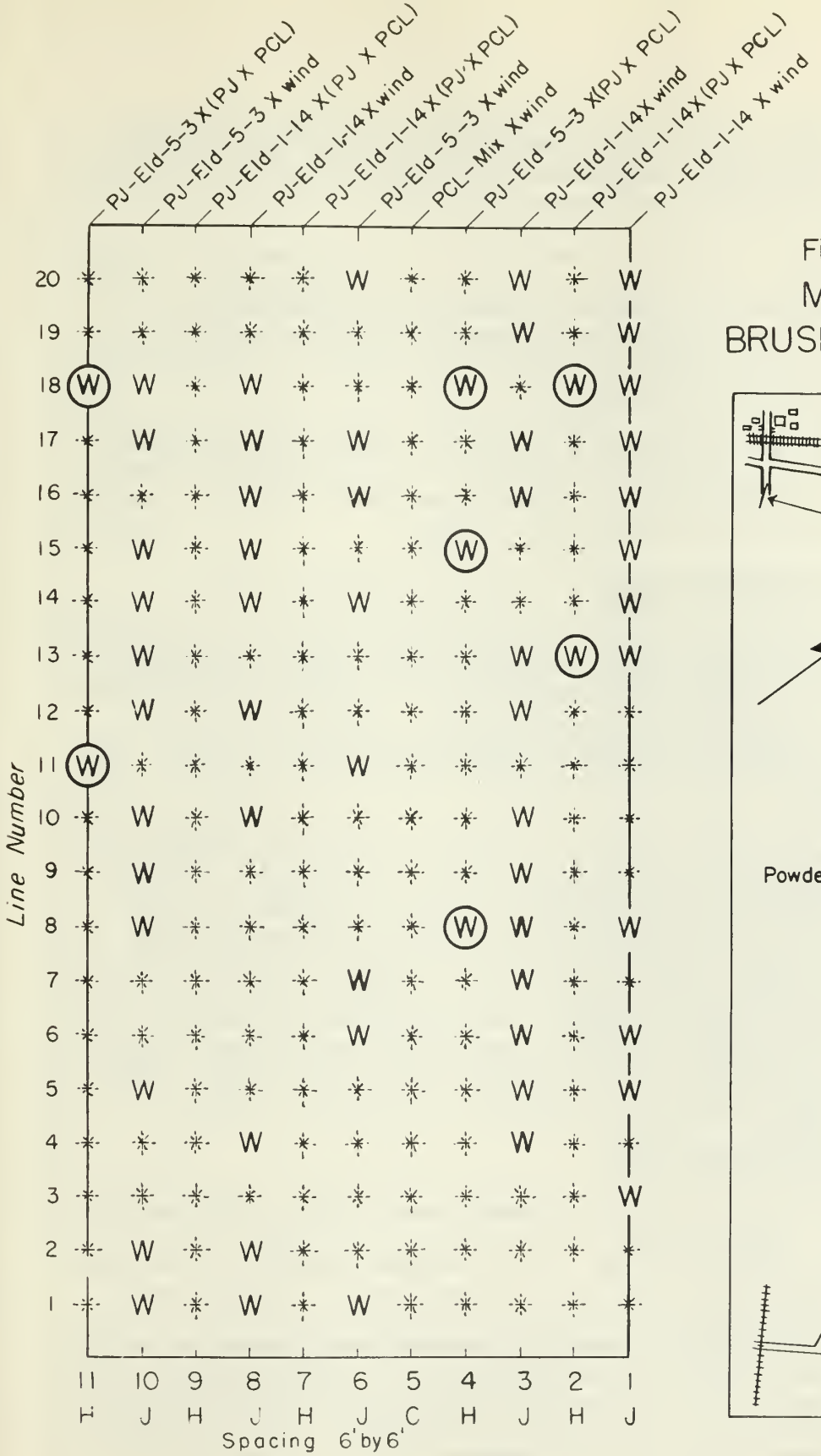
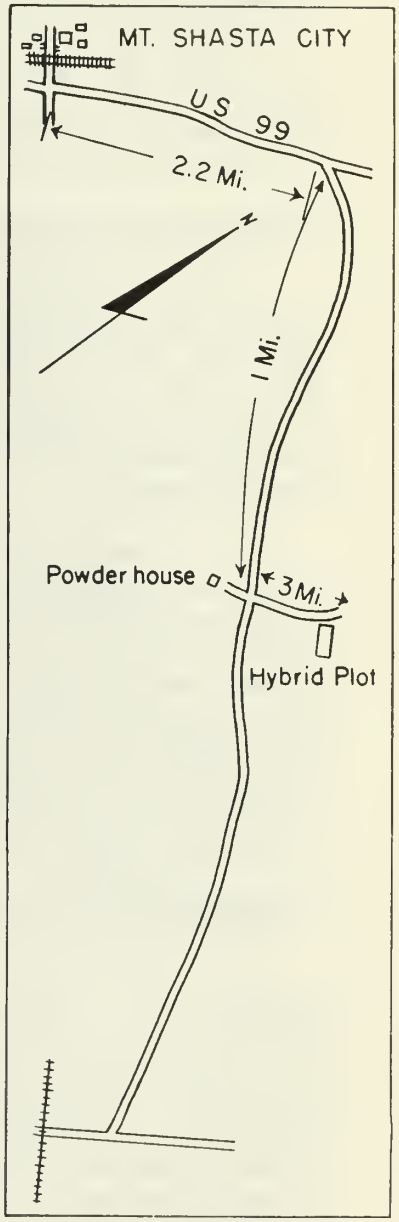


Figure 8

MT. SHASTA BRUSHFIELD SITE



Legend

Planted Trees Killed by Pine Reproduction Weevil (W) = Hybrids, 7 W = Jeffrey Pine, 55

H = Hybrids J = Jeffrey C = Coulter

where the reproduction weevil had caused very serious damage in the past. This site is about 1 mile southwest of Big Springs, parallel to Highway 89, and about 100 feet west of the right-of-way. The elevation of this area is about 4, 800 feet.

The McCloud Flat planting site is located on the McCloud District, Shasta National Forest. It is about 9 miles east of the District headquarters, and about 200 feet north of the Highway 89 right-of-way. This area is just a short distance northwest across the highway from the Forest Service Nursery site. The elevation at this site is about 3, 700 feet.

The Mt. Shasta planting site was selected in the Shasta Brushfield planting area at an elevation of about 4, 000 feet. This is on the Sacramento District of the Shasta National Forest, about 3 1/2 miles north of the town of Mt. Shasta.

Preparation of Planting Stock

The planting stock used in these tests was 2-0 bare root. Before the trees were lifted, a tag giving pedigree designation, nursery, and planting location was attached to each of the seedlings. The seedlings were dug on March 9, 1948, assembled in large bundles consisting of 11 packs of 20 seedlings each, and put in cold storage near Camino, California. Roots were cut at 18 inches from the root-collar.

These preparations were made in accordance with planting plans drawn up by the Institute of Forest Genetics. The planting plans are given on the Institute's selection sheets, carbon copies of which were transmitted to the Forest Insect Laboratory before the planting. These sheets show for each seedling its parentage, pedigree designation (offspring number), nursery location, age and height at time of digging, field or plantation location, and other data. Knowing the nursery location makes it possible to get the germination record, 1-year height, and any other data which pertains to each seedling, should it prove desirable to do so.

Preparation of Planting Site

The Experiment Station had found through experience in planting that rodent damage, particularly from rabbits, was very light in areas where the brush cover had been completely removed. For that reason, all brush was removed from each site before planting. The brush was cleared for a distance of at least 20 feet beyond the actual planting area to provide an ample isolation strip. Clearing was done by the local national forest staff of the Forest Service, using a hired bulldozer at Big Springs and Shasta and through a Forest Service dozer at McCloud Flat. Care was exercised in the clearing operation to disturb the top soil as little as possible.

After the areas were cleared of brush, they were staked out with 2-inch by 2-inch by 6-foot redwood stakes. These stakes were set at the end of each row and each line, and the row number and species were stenciled on each row stake. The designation on the line stakes was the line number only, as each line contained a variety of species.

After the area was staked, a hole 18 inches deep by 12 inches wide was dug with a shovel at the position where each tree was to be planted. A hole of this dimension was necessary because of the size of the root system on the average seedling. Both the digging of the holes and the staking of the areas were done by the Forest Service men under the supervision of the Forest Insect Laboratory.

Planting

It was originally planned to plant these areas starting March 25, 1948. Late spring snows delayed the planting on the Mt. Shasta and Big Springs sites for 4 weeks and on the McCloud Flat site for 6 weeks. The Mt. Shasta area was planted April 20, the Big Springs area April 21, and the McCloud Flat May 4.

The Mt. Shasta and Big Springs areas were planted jointly by members of all three agencies. Personnel from the Institute brought the trees from Placerville April 19 and assisted with the planting of these two areas the next two days. The trees for the McCloud Flat area were left in cold storage at Placerville and were transported by the author on May 3 and planted the next day. The planting work was very carefully done on all areas. The general procedure was for one man to hold the tree in the planting hole while another man shoveled in the dirt from the side. The man holding the tree kept the roots spread out and tamped the dirt in firmly as it was shoveled in. A saucer-shaped area of dirt, about 2 feet across, was formed around the planted tree and this depression was filled with water to moisten and settle the soil around the roots. The stock used at Mt. Shasta and Big Springs was in storage for a period of 6 weeks, that used at McCloud Flat for 8 weeks. The terminals on the Coulter pines appeared to be slightly wilted at the time of planting, but those on the Jeffrey and hybrids appeared to be in good shape.

Maintaining Weevil Populations

To be assured of an adequate population of weevils for these tests, weevil-infested material was collected from naturally infested pine plantations in the Mt. Shasta brushfield within a radius of about 100 yards of the experimental planting, and concentrated in the experimental area in the spring of 1951. In 1952, indications were that this procedure would not need to be continued because of natural infestation within the experimental area. In the

spring of 1952, the weevil was controlled on about 2,000 acres of adjacent plantations by application of DDT from an airplane. To protect the study of hybrid resistance, trees within the experimental area were covered by paper bags (figure 9).

Figure 9.--Paper bags protected trees in Mt. Shasta planting from DDT to maintain experimental weevil population when nearby plantation was sprayed.

The Big Springs area had no nearby natural sources of an adequate weevil population because no pines remained in the area. Therefore infested material was collected from the Burney Springs plantation and placed within the confines of the Big Springs experimental area in 1951 and 1952. Enough infested trees were used to simulate about 15 percent infestation.

No infested material was placed in the McCloud Flat experimental plot because of the proximity of the McCloud nursery.

Maintaining Plots and Records

During mid-summer after the original planting, each planted tree was thoroughly watered. The next spring, all failed spots were replanted; this required 45 Jeffrey pines, 34 hybrids, and 33 Coulter pines.

Annual inspections were made of each of the plantings for a period of 9 years to check on mortality. At the end of 3 seasons of growth, each living tree was measured for total and annual height growth by measuring the distance between internodes and a progress report prepared on growth and survival up to that time. 2/ At the end of 5 years another progress report was prepared reporting preliminary results on the resistance of the hybrids to the pine reproduction weevil. 3/

In 1955 all defective stakes were replaced and new numbers painted on all stakes. In 1956 the brush competition was removed from half of the Mt. Shasta plantation because height growth seemed to be slowing down in this plantation. In 1956 each tree was remeasured for periodic height growth, and total height for the 9-year growing period was obtained. In 1957 large wooden signs explaining the purpose of the project were placed at the Big Springs and Mt. Shasta plantings by the Lassen and Shasta National Forests.

2/ Hall, Ralph C.
1950 tests of hybrid pines for resistance to the reproduction weevil under field conditions. Report of progress 1948 through 1950. Agricultural Research Service, Bureau of Entomology and Plant Quarantine. 13 pp. (Processed.)

3/ _____
1953 tests of hybrid pines for resistance to the reproduction weevil under field conditions. Report of progress 1951 and 1952. Agricultural Research Service, Bureau of Entomology and Plant Quarantine. Special Report BK-20, 3 pp. (Processed.)

Table 1. --Mortality records on hybrid plantings on the Shasta and Lassen National Forests, 1948-1956

Species	Original number trees planted plus replants	Planting failure number killed 1st two years	Number living 1950	Killed by weevil				Rodent damage number killed	Other number killed	Total number trees remaining
				1951 - 1952	1953 - 1956	Total number	Percent 1/			
					Big Springs					
Jeffrey	112	19	93	12	10	22	23.7	0	0	71
Coulter	34	22	12	0	0	0	0.0	0	12	0
Hybrid	112	17	95	1	3	4	4.2	0	0	91
					Mt. Shasta					
Jeffrey	111	25	86	38	17	55	64.0	0	0	31
Coulter	26	13	13	0	0	0	0.0	0	0	13
Hybrid	106	10	96	6	1	7	7.3	0	0	89
					McCloud					
Jeffrey	122	53	69	0	0	0	0.0	40	0	29
Coulter	33	28	5	0	0	0	0.0	5	0	0
Hybrid	116	43	73	0	0	0	0.0	52	0	21
					Mt. Shasta and Big Springs					
Jeffrey	223	44	179	50	27	77	43.0	0	0	102
Coulter	60	35	25	0	0	0	0.0	0	12	13
Hybrid	218	27	191	7	4	11	5.7	0	0	180

1/ Percent killed by weevil based on those living in 1950.

Table 2. --Mortality of planted seedlings, first and second year after planting

Item	Jeffrey parent	Hybrid	Coulter parent
BIG SPRINGS			
Original Number Planted	100	100	20
Percent dead first year	12.0	12.0	70.0
Number replanted	12	12	14
Percent replants dead first year	58.3	33.3	57.1
Percent original stock dead 2nd year	0	1.0	0
Total percent original stock dead	12.0	13.0	70.0
MT. SHASTA			
Original Number Planted	100	100	20
Percent dead first year	11.0	6.0	30.0
Number replanted	11	6	6
Percent replants dead first year	63.6	16.7	100.0
Percent original stock dead 2nd year	7.0	1.0	10.0
Total percent original stock dead	18.0	7.0	40.0
McCLOUD			
Original Number Planted	100	100	20
Percent dead first year	22.0	16.0	65.0
Number replanted	22	16	13
Percent replants dead first year	95.5	75.0	100.0
Percent original stock dead 2nd year	10.0	10.0	15.0
Total percent original stand dead	32.0	26.0	80.0
Percent killed by gophers, winter '49	11.0	16.0	0
Total percent original stock dead	43.0	42.0	80.0
TOTAL			
Original Number Planted	300	300	60
Percent dead first year	15.0	11.3	55.0
Number replanted	45	34	33
Percent replants dead first year	77.8	50.0	81.8
Percent original stock dead 2nd year	5.7	4.0	8.3
Total percent original stand dead	20.7	15.3	63.3
Total percent original stock and replants dead (except gopher damage)	28.4	18.9	68.8

Difference in survival between Jeffrey Parent and hybrid, 9.5 percent, has an X^2 value of 8.33, which is highly significant.

Table 3.--Effect of size of planting stock on planting survival for the first two years after planting in the Big Springs and Mt. Shasta plantings

Size class	Number planted		Number surviving		Percent surviving	
Feet	Jeffrey	Hybrid	Jeffrey	Hybrid	Jeffrey	Hybrid
.30 - .49	58	1	55	1	94.8	100.0
.50 - .69	119	59	95	55	79.8	93.2
.70 - .89	23	115	15	100	65.2	86.9
.90 - 1.00	0	24	--	17	--	70.8
1.10 - 1.20	0	1	--	0	--	0

Table 4.--Correlation between planted height to total height Jeffrey pine and hybrid

Planting	Species	r	Standard error of estimate	
			Actual	Percent
Shasta	Jeffrey	+ .4697 **	± 1.05	23.5
Big Springs	Jeffrey	+ .2200 *	± 1.15	28.1
McCloud	Jeffrey	+ .4437 *	± .70	30.0
Shasta	Hybrid	+ .2503 *	± 1.25	23.8
Big Springs	Hybrid	+ .2749 *	± 1.02	19.0
McCloud	Hybrid	+ .0716 NS	± .99	33.0

* Significant

** Highly significant

NS Not significant

Table 5.--Comparison of total height growth in paired rows of Jeffrey parent and Jeffrey x (Jeffrey x Coulter) hybrid in three plantations for 9-year period, 1948 through 1956

Planting	Jeffrey	Hybrid	Analysis of variance				
	Total	Height growth in feet	Source	D.F.	SS	MS	F
			Total	9	176		
Big Springs	4.68	5.36	Between rows	4	23		
			Between varieties	1	116	116	13**
			Discrepancy	4	37	9.2	
			Total	9	358		
Shasta	4.18	5.32	Between rows	4	67		
			Between varieties	1	270	270	51**
			Discrepancy	4	21	5.25	
			Total	9	322		
McCloud	2.22	3.02	Between rows	4	150		
			Between varieties	1	160	160	53**
			Discrepancy	4	12	3.0	
			Total	29	4,251		
All plantings	3.69	4.53	Between rows	14	3,635		
			Between varieties	1	529	529	85**
			Discrepancy	14	87	6.2	

**Highly significant

Table 6.--Planting design, field tests of hybrid resistance to Cylindrocopturus damage 1/

Line number	Row number										
	1	2	3	4	5	6	7	8	9	10	11
1	J	H	J	H	C	J	H	J	H	J	H
2	J	H	J	H	C	J	H	J	H	J	H
3	J	H	J	H	C	J	H	J	H	J	H
4	J	H	J	H	C	J	H	J	H	J	H
5	J	H	J	H	C	J	H	J	H	J	H
6	J	H	J	H	C	J	H	J	H	J	H
7	J	H	J	H	C	J	H	J	H	J	H
8	J	H	J	H	C	J	H	J	H	J	H
9	J	H	J	H	C	J	H	J	H	J	H
10	J	H	J	H	C	J	H	J	H	J	H
11	J	H	J	H	C	J	H	J	H	J	H
12	J	H	J	H	C	J	H	J	H	J	H
13	J	H	J	H	C	J	H	J	H	J	H
14	J	H	J	H	C	J	H	J	H	J	H
15	J	H	J	H	C	J	H	J	H	J	H
16	J	H	J	H	C	J	H	J	H	J	H
17	J	H	J	H	C	J	H	J	H	J	H
18	J	H	J	H	C	J	H	J	H	J	H
19	J	H	J	H	C	J	H	J	H	J	H
20	J	H	J	H	C	J	H	J	H	J	H

1/ Symbols:

J = P. jeffreyi

C = P. coulteri

H = Hybrid: P. jeffreyi x (P. jeffreyi x P. coulteri)